# AN INTEGRATED APPROACH TO RISK MANAGEMENT AND RISK ASSESSMENT

G. Jeffrey Robinette
Engineering Directorate
Systems Engineering Division
2530 Loop Road West
Wright Patterson AFB, OH 45433-7101

Janet S. Marshall
Comptroller Directorate
Acquisition Cost Division
1865 Fourth Street
Wright Patterson AFB, OH 45433-7123

**Abstract.** This paper describes the work performed by the Air Force Aeronautical Systems Center (ASC) Integrated Risk Management (IRM) team in implementing the DoD risk management structure[1]. It also describes the implementation of the Aeronautical Systems Center's Integrated Risk Assessment (IRA) approach.

This paper discusses the three parts of an integrated risk assessment: the Technical Assessment, the Schedule Assessment and the Cost Estimate. It covers their interaction and interrelationship and the tools used in accomplishing each of the three parts. The highlights of several different risk assessments performed at ASC are presented to show contrasting implementations of the IRA approach.

## INTRODUCTION

Even though the Aeronautical Systems Center (ASC), Wright-Patterson AFB, OH has practiced risk management for some time, it did not reach its full potential until the ASC Commander formed the Integrated Risk Management (IRM) Focus Area[2] in April 1997. The Comptroller Directorate, in partnership with the Engineering Directorate, have developed, implemented and are currently maintaining a world class risk management process for ASC. Mr. Robinette and Ms. Marshall were chosen to lead a multi-functional team to tackle the challenge of implementing and executing IRM for ASC.

The Engineering and Comptroller organizations have built a seamless, cohesive working relationship that has resulted in superior products and services for the Center. The IRM team provides training, guidance and tools to all programs within ASC as well as other services, DoD organizations and industry counterparts[3].

In an era of diminishing resources, funding, time and qualified people, we are more limited now than in the recent past. Acquisition reform initiatives demand that we focus these limited resources on the elements most critical to the success of a program. Properly administered risk management allows us to determine when and where to focus these limited resources.

Previously, ASC program offices did not realize the full potential of risk management as a tool to manage programs. Risk management helps program managers determine when and where to apply oversight verses insight, or decide no management intervention is required as well as providing a basis to allocate scarce resources. This called for an *'anticipatory, proactive'* process.

The IRM team first set the vision – integrate risk management as an inherent aspect of developing and managing executable programs. The team's objective was to provide program offices with risk management guidance, assistance, training and tools. Once the team fully understood the magnitude of the task, they attacked the tough job of implementing the objectives.

Implementing objectives involved determining where the weaknesses were and what needed to be done to minimize any deficiencies. The first step in accomplishing this was to survey all ASC program offices to determine their needs and develop a baseline of where the Center was in using risk management as a management tool. The following four deficiencies were identified.[4]


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1. The risk management process was weakly structured or 'ad hoc'.
2. The risk assessment portion of the risk management process was too subjective and not adequately documented.
3. The emphasis of the risk assessment process was generally on the *uncertainty* associated with a specific event occurring, with less attention given to the *consequence* of the event occurring.
4. Risk handling plans were often unlinked; and prepared on an as-needed basis.

The IRM team's plan was to correct all these shortcomings while developing world class risk management and risk assessment processes.

## RISK MANAGEMENT OVERVIEW

As acquisition reform moved the Government from oversight to insight and from strictly risk avoidance to risk management, it was apparent that a comprehensive risk management process needed to be developed. This process needed to provide the tools and a solid strategy to attain affordable systems with superior capability, while strengthening the industrial base. All successful strategies contain the same four elements[1] listed in the DoD Risk Management structure presented in Figure 1.

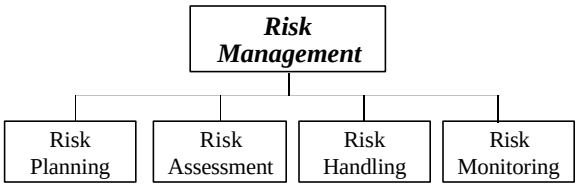


**FIGURE 1. RISK MANAGEMENT STRUCTURE**

The risk management process activities fall generally into four broad elements: Risk Planning, Risk Assessment, Risk Handling and Risk Monitoring. To understand these elements it is important to first understand the meaning of risk. ***Risk*** is the possibility of something negative happening to your program; such as loss or injury, some disadvantage or giving some advantage to your enemy. It is the measure of the inability of being able to achieve desired objectives. All risk has at least two components: the probability a negative event will occur and the consequence if that event does occur. Without a doubt, what is most misunderstood is that all risk is about the future and all facts are in the past. However, if you are currently dealing with a situation, it is not a risk, it is a problem. ***Risk Management*** is the act or practice of controlling risk. Risk Management includes developing a risk management plan for your program, identifying and tracking risk areas, developing risk handling options, monitoring risks and performing risk assessments to determine how risks have changed and how they impact performance, schedule and cost.

## INTEGRATED RISK MANAGEMENT

The acquisition environment has changed dramatically in the past several years. Acquisition reform and lightening bolt initiatives have changed the Air Force's acquisition management process. The Center's Integrated Risk Management approach was structured to support these changes, and is meant to be part of a program's day-to-day operations, not something separate from the program.

The development of IRM at ASC started with the following premise: 1) projects can't be truly successful without risk management and 2) to make risk management effective within a project, risk management must be culturally ingrained in the organization as well as a project discipline. Given this challenge, the following goal was set: instill risk management into the ASC culture and provide the tools and training for disciplined risk management. In addition to this, our approach was to make IRM a facilitating process and insure it complements and supports other current management processes already in place.

What makes risk management integrated? Risk management becomes integrated when the approach is synergistic. That is when one part of the process works with another to produce an output that is more then the sum of the two parts. At ASC, the integrated approach to risk management mirrors the general risk management process, is consistent with the DoD structure and has continuous feedback. The major parts of IRM are listed below:

*Risk Planning* is the process of developing and documenting organized, comprehensive and interactive strategies and methods for performing risk management. Risk planning includes a plan to identify and track risk areas, develop risk mitigation plans, perform risk assessments to determine how risks have changed, and plan for adequate resources. The plan documents the who, what, when and where of risk management.

*Risk Assessment* is the process of identifying and analyzing risks to increase the likelihood of meeting performance, schedule and cost objectives. It includes risk identification and risk analysis. Risk identification is the process of examining the program, processes, requirements and critical technologies to identify and document risk areas. Risk analysis is the process of examining each identified risk, isolating the cause, and determining the impact. Risk impact is defined in terms of its probability of occurrence, its consequences, and its relationship to other risk areas or processes. The ASC integrated approach includes a Technical Assess-

ment, Schedule Assessment and a Cost Estimate to identify potential risks and impacts.

*Risk Handling* is the process that identifies, evaluates, selects and implements options in order to set risk at acceptable levels given program constraints and objectives. This includes the specifics on what should be done, when it should be accomplished, who is responsible, and the cost impact. The most appropriate strategy is selected from these handling options and documented in a risk handling plan.

There are several risk handling options at the discretion of the program manager. The first choice for a risk handling option is generally risk avoidance. This is changing the requirements to a level that lowers the risk to an acceptable level, but still meets the program objectives. However, risk control (or risk mitigation) is the most used form of risk handling. This option involves taking active steps to minimize the risks' impact on program objectives. Another option is risk prevention or transfer, also called risk abatement. This approach re-allocates design requirements to those system elements that can achieve the system requirements at a lower risk. The last option is risk assumption. With this approach the program will take or accept the risk without engaging in any special effort to control the risk.

*Risk Monitoring* is the process that systematically tracks and evaluates the performance of risk handling actions against established metrics or indicators throughout the acquisition process and develops and executes further risk handling options as appropriate.

Risk monitoring is truly a management function. It is important for this part of the risk management process to work so that well-established indicators and metrics are developed and used. Indicators are parameters that answer the question, "How am I doing today?" While metrics address, "How I am doing today compared to how I was doing yesterday?" To make these work it is important to determine what parameters should be measured.

In the IRM approach it is important that a program start with a risk driven acquisition strategy. Through periodic risk assessments the program is then able to take a calculated risk for a 'known' pay-off to achieve desired performance. To achieve the maximum payoff for the lowest cost in the shortest schedule, risk management must be practiced throughout the life of the program.

## INTEGRATED RISK ASSESSMENT

The application of synergism makes the ASC risk assessment process integrated. This is specifically accomplished by having all parts of the assessment process work very closely together and by requiring all players, the program office, the contractor and the customer, to participate in all stages of the assessment. Synergy lets us discover things together that we are less likely to discover alone.

Integrated Risk Assessments (IRAs) are accomplished throughout the life cycle of a program. Early in the program's life cycle, it is critical to use the IRA results to help develop the program's acquisition strategy as well as assisting in cost, schedule and performance trades. Then during source selection, an IRA is used to make an assessment of the contractors' proposals. After contract award, IRAs are completed during major –milestones reviews or whenever deemed necessary to assess the program's risks.

This paper will focus on a baseline IRA in which the IPT is starting from scratch. In other words, there is not a baseline technical assessment, program schedule or cost estimate. In an IRA update, this process is slightly modified depending on what the program team has already developed and is in place.

To start the Integrated Risk Assessment (IRA) a risk assessment team is formed. This 'risk' team consists of the program Integrated Product Team or IPT and some or all of the following: subject matter experts, a lead for the Technical Assessment (TA), Schedule Assessment (SA) and Cost Estimate (CE), advisors and a facilitator. This collection of evaluators forms the Risk IPT (R-IPT), see Figure 2. Within this team will be people who will develop the new schedule and the new cost estimate. However, the program IPT is responsible for managing the program; and is ultimately

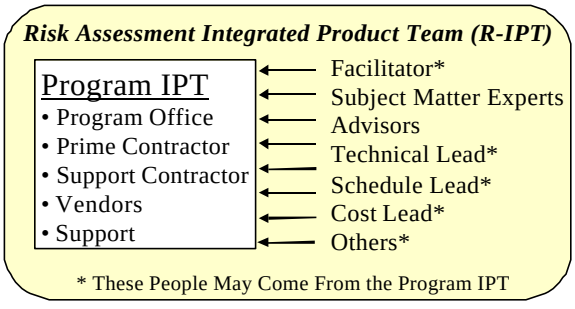


**FIGURE 2. RISK IPT**

responsible for the IRA.

In this process differences are an opportunity, rather than a threat. In the risk management business two things are true. "If we do not risk anything we risk even more." And "Nothing is more dangerous than an idea when it is the only one you have."[5] So we start with the understanding that it takes some risk to gain some performance. And by bringing the entire team together and keeping them together throughout the en-

tire process, the opportunity for more than one idea for each situation is created.

The three parts of the IRA are the Technical Assessment, the Schedule Assessment and the Cost Estimate. All three pieces of an IRA begin at the same time. The technical folks begin their portion by holding a session with all applicable members to assess the potential risks in the program. Concurrently, designated team members are developing a baseline schedule and a baseline cost estimate. These three groups work very closely to ensure each group understands what the other groups need. For example, the schedule people attend the technical assessment meetings to ensure they understand the potential risks that might impact the schedule. In turn, they provide the technical folks with an understanding of what they need, to do an assessment of the schedule. The cost folks work very closely with both the technical and schedule folks to ensure they fully understand the risks identified and how these risks impact cost. The following are the general steps to perform each of the assessments.

*Technical Assessment (TA)*
- Requirements Review
- Risk Methodology
- Risk Identification
- Risk Analysis
- Administration

*Schedule Assessment (SA)*
- Establish Schedule
- Understand TA Risk Areas
- Determine Task Durations
- Run Simulation
- Analyze Results
- Document And Present

*Cost Estimate (CE)*
- Define And Plan
- Research, Collect & Analyze Data
- Formulate Estimate (Risk Quantification)
- Review & Present
- Document

It is important to remember that the primary purpose of the IRA is to identify and analyze program risks in order to address the challenges of meeting performance, schedule and cost objectives. The following paragraphs describe each of these areas and how they work together to produce the best possible result.

The Technical Assessment (TA) is the first step in any IRA. The TA must ensure the technical foundation is within acceptable risks and defines the technical inputs to the schedule assessment and the cost estimate. Figure 3 outlines the five steps in the ASC technical assessment process.

**IRA – TECHNICAL ASSESSMENT**

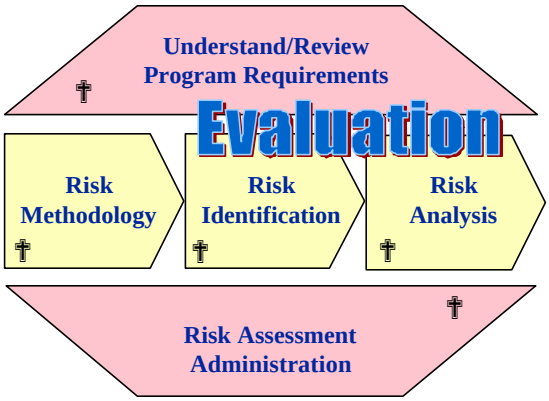


**FIGURE 3. TECHNICAL ASSESSMENT**

*Requirements Review.* The R-IPT must understand and review the program requirements, objectives, goals, and constraints. They should, at a minimum, review items such as, product description, planning documents, historical information, test and evaluation plans, system performance requirements, system specifications, statement of work or objectives, etc. A close look at the risk management plan is also in order at the beginning of the IRA. A full understanding of the scope of work and definitions of all terms used in the IRA must be established and documented before the evaluation (risk identification and risk analysis) begins.

*Review and/or Determine Risk Assessment Methodology.* Each program or assessment is different from the last one, so different methodologies for performing the TA may be required. The recommended technical assessment methodology used at ASC is the Probability/Consequence approach. To implement this approach the Probability/Consequence Screening (P/CS) tool is used. This tool is government developed software based on an approach used by Air Force Material Command (AFMC) in 1993. Details of the P/CS tool will be discussed later in this paper.

Other methods may be used where appropriate. It is important to fully understand the methods planned for use in the schedule assessment and the cost estimate. These approaches may impact what is needed from the technical assessment.

*Risk Identification – Evaluation.* Risk identification, and the next step, risk analysis, also referred to as the evaluation process. Risk identification specifies, describes and documents program risks and their sensitivities to other risks. Sources of risk are generally divided or partitioned into technical, schedule and cost. Note that any risk identified may fall into more than one category (technical, schedule and cost).

Risk identification is the application of systems engineering along with some technical art. The approach is to get the R-IPT together, use a facilitator to identify and review the risks. The R-IPT should include people who are educated and trained in the technology or acquisition being addressed by the assessment. Subject matter experts are always a good idea because the most experienced people product the best results. Subjective technical judgment may be the best indicator of the real risks.

*Risk Analysis – Evaluation.* Risk analysis, the second part of the evaluation process, is where the R-IPT analyzes any empirical data available to quantify risks in terms of probability of occurrence and the eventual consequences if the risk does occur. The magnitude of the consequences needs to be quantified regarding impact to performance, schedule and cost. The R-IPT must ensure that consequences are not double counted. For example, a technical risk that impacts schedule and cost, needs to be analyzed, so that the same risk is not counted again in the cost estimate.

The severity of the consequences should be determined against the previously agreed-to definitions for performance, schedule and cost. Performance consequences are characterized in terms of lost or degraded performance. Schedule consequences are captured in terms of additional task duration for the schedule tasks that are impacted by the particular risk. Each task duration impacted must specify a minimum, a most likely and a maximum time duration. Cost impacts are captured in terms of additional resources or assets required.

All data is analyzed to determine the level (High, Moderate, Low) of each risk. This determination must be made against established definitions. It is important that sufficient information (annotations) is collected about each risk and its consequences to form a detailed audit trail.

*Risk Assessment Administration.* In the technical assessment, risks, risk owners and associated consequences (performance, cost and schedule) are documented as part of the total IRA.

When the Probability/ Consequence Screening (P/CS) tool is used for the evaluation process, most of the information required from the technical assessment is automatically captured for use in the subsequent assessment steps.

### IRA – P/CS Tool

Probability/Consequence Screening or P/CS is a standalone program that was developed by ASC using Microsoft Visual Basic® 5.0. It is quick and easy to use and can be started at any time during the program life cycle. It provides a standard technique that offers repeatable results. All the information gathered during the assessment, including the results and rationale are saved to a data file, which allows the assessment to be easily updated at anytime.

When using the P/CS approach, the user enters the most advantageous programmatic unit at which to aggregate risk. Usually, this unit is at the program requirement level, although other elements or components of the program are used and work well. For each requirement, the user defines the risks involved with meeting that requirement. Each risk is then assessed for a Probability of Occurrence (PF) and a Consequence of Occurrence (CF) associated with performance, schedule, and cost. The definitions of the PF and CF levels are defined by each program prior to the assessment.

A powerful feature provided in the P/CS software is the ability to link the program assessment to files containing available schedule and cost information. This feature allows the user to build a data package that includes all program information relative to the assessment at that time. Using the schedule and cost links on the assessment form or page, the impact on the current schedule and cost estimate can be directly shown. The assessment page also offers a text field with which to record the rationale used in the selection of PF and CF values. Due to the high personnel turnover in most programs, it is especially important to document the risk assessment/rationale for future program reviews, and assessments updates (See Figure 4).

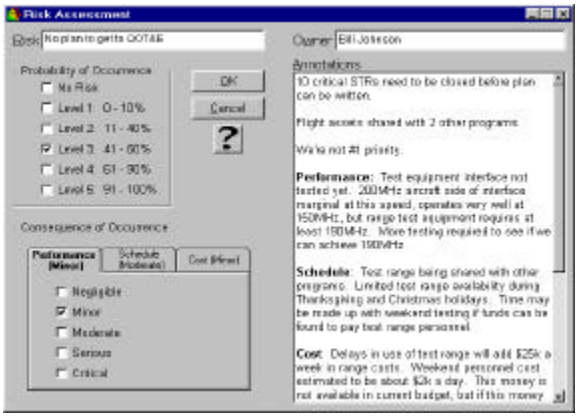


**FIGURE 4. P/CS RISK ASSESSMENT PAGE**

The tool determines the risk score by placing each risk in a consequence-screening matrix by its PF and CF values. The user has complete freedom to define which areas within the matrix are high, moderate, and low risk. The matrix can be tailored to display all of the requirement risk scores, only the performance, schedule, or cost risk scores, or only the highest score for each risk. The matrix (Figure 5) can be printed or exported to point papers, presentations, briefings, etc.

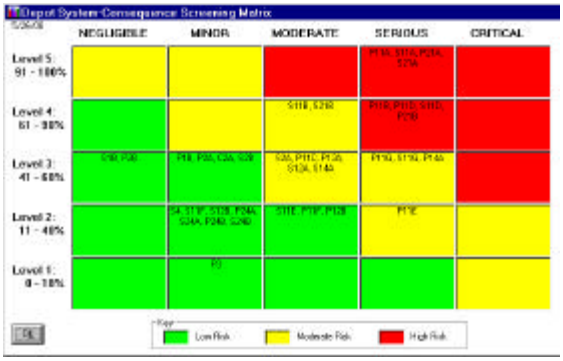


**FIGURE 5. P/CS MATRIX**

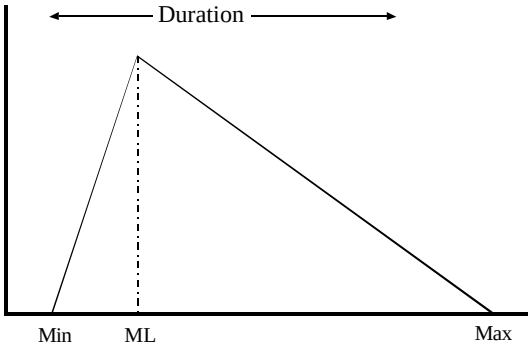


**FIGURE 6. TRIANGULAR DISTRIBUTION**

### IRA – SCHEDULE ASSESSMENT

There are several different approaches to assessing schedule risks. The method described in the next few paragraphs is a Schedule Assessment (SA) utilizing a network-based approach. The tools mainly used at ASC for this type of approach are Microsoft Project® and Risk Plus (Risk+©)[7]. The steps in this process are described below:

*Establish Baseline Schedule.* The first step in the schedule assessment is to establish a network-based baseline schedule. At ASC, the main software package used is to develop a networked-based schedule is Microsoft Project®. Utilizing existing government and contractor schedules, programmatic documents, and talking with program experts, the IPT or R-IPT develops a baseline schedule. During this effort, the R-IPT works with schedule experts to understand the program and lay out the program as it exists today. The R-IPT reviews the logic and duration of all activities for accuracy.

*Understand the TA Risks.* The R-IPT works to understand the technical risks identified in the technical assessment. Normally, moderate to high risks identified are evaluated to determine what program schedule activities are impacted. Once the affected activities are identified, the R-IPT assigns a minimum, most likely and maximum duration for each activity. These inputs are based on historical/analogous information and the technical team's expertise. The logic of the network is again reviewed by the IPT.

The minimum, most likely (ML) and maximum task durations are needed to run the Monte Carlo simulation. The probability distribution function (PDF) normally used is a triangular distribution[6] (Figure 6).

*Evaluate the Schedule.* The schedule team then analyzes the technical inputs provided, discusses the technical inputs with the technical team, and then inputs the range of durations (Min, ML and Max) into the network using Risk+© software[8] (ProjectGear Inc.). This software tool is a comprehensive risk analysis tool that integrates seamlessly with Microsoft Project to quantify the cost and schedule uncertainty.

*Run the Schedule Simulation.* Once the ranges of durations are input, the team runs the simulation. The simulation is Monte Carlo based and several hundred iterations are run to determine the probability distribution (See Figure 7).

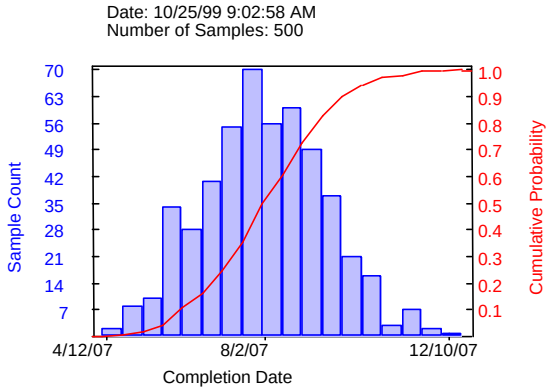


**FIGURE 7. SAMPLE OUTPUT**

*Analyze Results* During this step, the R-IPT analyzes the results of the simulation. The assessment is re-evaluated and re-run, as necessary based on the revised technical inputs of the Minimum/Most Likely/Maximum. The outputs of the assessment are depicted by histograms and probability distributions. The final schedule assessment results are reviewed by the entire R-IPT and then provided to the cost estimator This translation of schedule impacts to cost is critical to ensure that the R-IPT understands the resultant schedule impacts.

*Document and Present.* The R-IPT fully documents and presents the schedule assessment as part of

the IRA. As the R-IPT is conducting the Schedule Assessment, the R-IPT is concurrently working to develop the cost estimate. The following steps are used to develop a cost estimate and incorporate risks into the estimate.

### IRA – COST ESTIMATE

*Define and Plan.* The R-IPT first determines the resources required, scope of effort, level of detail required, program requirements, begins identifying alternatives and works with the entire R-IPT to understand risk areas and impacts.

*Research, Collect and Analyze Data.* The team then determines the initial methodologies to be used in the estimate. Then they identify, obtain and analyze appropriate data sources (i.e., analogous systems, cost databases, research projects, parametric data (size, weight, volume, etc)).

*Formulate Estimate (Risk Quantification)* In this step the R-IPT reviews and quantifies technical risks and schedule inputs and then generates the estimate using appropriate methodologies. Quantification of the technical and schedule risks involves developing Minimum, Most Likely and Maximum inputs, which are then fed into a Monte Carlo simulation which calculates the probability distribution for the estimate (See Figure 8). The cost risk assessment tool used most frequently at ASC is Crystal Ball[8], by Decisioneering. It is a Microsoft Excel Add-in tool that uses Monte Carlo simulation to help analyze the risks and uncertainties associated with spreadsheet models. Features include sensitivity analysis, correlation, precision control, and distribution fitting to historical data. Lastly, the estimate is reviewed by the IPT and the R-IPT for realism and completeness.

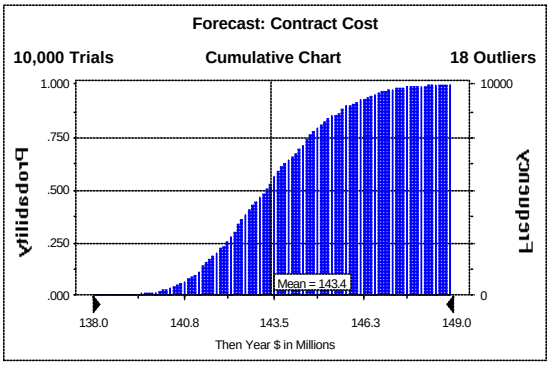


**FIGURE 8. COST DISTRIBUTION**

*Formal Review and Presentation.* The cost estimate is presented along with the technical and schedule assessment results senior level decision makers.

*Formal Documentation.* The cost estimate is fully documented with supporting technical and schedule assessments.

### ASSESSMENT APPROACHES

The following examples are presented to illustrate how the ASC IRA process has the flexibility to accommodate different program needs or desires. All these assessments had the same objective, an executable program; but attacked the assessment process differently. Even when the approach is different, the same tools can be used to accomplish the assessment.

One IRA performed involved an **F-15** program that had forty-seven test program sets (TPSs) in various levels of development. Some were complete and in use, some needed modification, some were in various stages of development. Our approach was to list all forty-seven TPSs in the P/CS tool as requirements and begin to determine the risks associated with each TPS.

The **F-22** approach is unique to-date but has potential to other large programs. Each of the nine F-22 Integrated Product Teams (IPTs) produced a P/CS matrix to summarize their risks. A senior roll-up R-IPT combined the inputs from the nine IPTs to produce a single matrix for the program director. This required consistent definitions across the IPTs and required the roll-up R-IPT to sort the list to summary level for the director. From this, another iteration was done to take the risks to the portfolio level. One advantage of this approach was that there was top down attention to critical risks and bottoms up work on the risks critical to each major part of the F-22.

In another assessment, a **B-1** review team spent several weeks looking over the program's 1800 tasks-to-go to determine the most critical. The approach was to take the eighty most critical schedule tasks and list them as requirements in the P/CS tool. After the R-IPT accomplished the technical assessment, Risk+© was run as part of the schedule assessment to determine the most likely schedule. From the risk list a new schedule and cost estimate were produced. This proved to be a very efficient approach.

### FUTURE PLANS

Our future plans are to tie the P/CS tool more tightly to Microsoft Project®/Risk+© and Excel®/Crystal Ball® , making the connection more automatic. This enhancement will reduce the time to perform the assessment as well as improve the assessment results.

Our focus has been on two aspects of risk management, probability (likelihood) and severity (consequences). But, there is another aspect of risk management that has not been investigated at ASC. That is, frequency. How often does a risk occur and how often

do we anticipate its occurrence. This type of quantification could possibly lead to organization or Center wide process changes.

ASC continues to enhance the risk management toolbox. The IRM team is currently looking at adding some automated risk handling and monitoring tools to the toolbox as well as a Design Structure Matrix (DSM) tool.

## CONCLUSION

IRM *is* an inherent part of business at ASC. Over fifteen program offices have performed IRAs and well over fifteen-hundred personnel have been trained on the IRM and IRA concepts. With this well-defined risk management approach, ASC is better able to develop and manage executable programs.

In summary, any well run acquisition program must take some risk in order to accomplish some reasonable degree of performance improvement. The ASC IRM and IRA processes allow a program to take a reasonable risk for an expected return in performance. It is important to note that risk management is not an event , but a journey.[9] We are on a productive, rewarding risk management journey at ASC. You are either embroiled in "Crisis" Management or you have institutionalized "Risk" Management. When risk management is institutionalized program managers have the opportunity to use IRA results to manage their program. With this approach you have enough information so you, "Never bet more than you can afford to lose." Because sometimes the dragon wins.[10]

## ACKNOWLEDGMENT

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## AUTHORS

**Jeff Robinette** is a systems engineer in the ASC Engineering Directorate Home-Office. He is a technical expert in risk management and risk assessments and is a co-lead in developing and implementing the ASC IRM and IRA processes. He has spent five years as a risk management expert. He holds a Bachelors of Science Degree in Systems Engineering from Wright State University and a Masters of Science Degree in Electrical Engineering from the University of Dayton.

ASC/ENSI
2530 Loop Road West
Wright-Patterson AFB, OH 45433-7101
Phone: 937 255-5946
Fax: 937 656-4744

**Janet Marshall** is the Chief of the Estimating Section, Estimating & Scheduling Branch, Acquisition Cost Division, ASC. She has been the co-lead for IRM, consulting on the cost and schedule aspects of an IRA, for approximately three years. Janet holds a Bachelors of Science in Business/Psychology from Wright State University and a Masters of Science in Business Administration from Central Michigan University.

ASC/FMCE
1865 Fourth Street
Wright-Patterson AFB, OH 45433-7123
Phone: 937 656-5488
Fax: 937 656-7695